Specification

# METHOD FOR AN X-RAY ARRANGEMENT TO COMPENSATE SCATTERED RADIATION AND X-RAY APPARATUS

The invention concerns a method for an x-ray arrangement for compensation of scattered radiation, which x-ray arrangement comprises two x-ray systems with respectively one x-ray source and one x-ray detector. The invention moreover concerns an x-ray apparatus comprising two x-ray systems.

An x-ray apparatus of the type cited above, for example, is what is known as a biplane x-ray apparatus which is used for cardiological or neurological examinations and treatments of patients. Due to the configuration of the x-ray apparatus with two x-ray systems, it is possible to acquire two x-ray exposures of a body region of a patient practically simultaneously from different angles. This serves primarily to acquire spatial information of this body region.

However, the mutual influence of the two x-ray systems due to the x-ray radiation scattering from the body of the patient thereby turns out to be problematic. This scattered radiation is less-energetic x-ray radiation that is radiated from the body of the patient in all spatial directions upon irradiation of the patient if it is not uniform and doesn't contribute to the usable image information. The scattered radiation has the disadvantageous effect that the image quality of the x-ray image acquired by the x-ray system is degraded. Namely, the scattered radiation also disrupts that x-ray system from whose emitted x-ray radiation the scattered radiation results. However, the largest part of the scattered radiation is again emitted in the direction of the x-ray source of this x-ray system. However, if the x-ray source of the one x-ray system is located near the x-ray detector of the other x-ray system, the interference between the two x-ray systems is particularly large.

In x-ray systems which comprise x-ray image intensifiers as x-ray detectors, it is comparatively simple to compensate for the scattered radiation, in that the other x-ray system is always then switched "blind", i.e. unreceptive to x-ray radiation, while the one x-ray system is in operation. However, this has the disadvantage that only temporally displaced x-ray exposures of a patient can be acquired with the two x-ray systems of the biplane x-ray apparatus. A further disadvantage of this technique is that the possibility of switching blind does not exist in x-ray detectors in the form of solid state detectors, for example aSi detectors. In this case, one is therefore forced to work with reduced image rate in both x-ray systems, which constrains the user, or to select the effective image rate twice as high as the useable image rate, which, however, hinders the technical realization capability.

Radiation converters in the form of solid state detectors and x-ray image intensifiers are specified in DE 198 42 474 A1 which can be used in biplane x-ray apparatuses. The radiation converters are characterized in that they comprise an luminous layer that emits light upon being impinged by radiation, in particular x-ray radiation, whereby a controllable layer is associated with the luminous layer, which controllable layer is substantially radiation-permeable over its entire surface upon a first activation, and is radiation-impermeable over its entire surface given another activation. Scattered radiation influences or radiation not generated by arranged radiation emitters can be excluded from the signal evaluation in this manner, whereby the image quality can be improved. However, given simultaneous operation of two x-ray systems (for example, in a biplane x-ray apparatus), the influence of the scattered radiation can not be excluded in this manner.

The invention is therefore based on the object to specify a method or, respectively, an x-ray apparatus of the type cited above, such that the influence of the scattered radiation on the image quality is at least reduced.

According to the invention, this object is achieved by a method according to claim 1 as well as by an x-ray apparatus according to claim 4. According to the invention, a subject is preferably irradiated with the x-ray source of the first x-ray system at a specific position of the x-ray systems relative to one another, and a first x-ray scattered radiation image based on the x-ray radiation scattered on the subject is acquired for the second x-ray system with the x-ray detector of the second system, whose x-ray source is not operated during the operation of the x-ray source of the first system. In the same position of the x-ray systems relative to one another, the subject is irradiated with the x-ray source of the second x-ray system and a second x-ray scattered radiation image based on the x-ray radiation scattered on the subject is acquired for the first x-ray system by the x-ray detector of the first x-ray system, whose x-ray source is not operated during the operation of the x-ray source of the second system. The x-ray scattered radiation images acquired thusly are saved in order to subtract the saved second x-ray scattered radiation image from an x-ray image acquired with the first x-ray system or, respectively, to subtract the saved first x-ray scattered radiation image from an x-ray image acquired with the second x-ray system given simultaneous, partially displaced or completely displaced operation of the two x-ray systems, such that the influence of the scattered radiation originating from the second respective x-ray system on the x-ray image acquired by the first respective x-ray system is at least reduced, if not actually eliminated completely. The image quality of x-ray images acquired with the x-ray systems can thus be improved in this manner.

According to a variant of the invention, the x-ray scattered radiation images are acquired and saved under defined acquisition conditions for each x-ray system. The x-ray scattered radiation images are thereby appropriate for the image correction as long as the acquisition conditions remain unchanged in their acquisition as well as in the acquisition of subsequent x-ray images of a subject. The acquisition conditions thereby comprise the x-ray dose, the x-ray spectrum and the acquisition geometry. Since the x-ray scattered radiation images are actually proportional to the x-ray dose, it is possible, given a change of the x-ray dose for

the acquisition of further x-ray images, to scale an x-ray scattered radiation image that is consulted for the subtraction corresponding to the change of the x-ray dose. In this manner, given a change of the x-ray dose one is not forced to always acquire and save new x-ray scattered radiation images in order to compensate for the parasitic [sic] scattered radiation in acquired x-ray images of a subject.

A further variant of the invention provides to determine the x-ray scattered radiation image used for an x-ray system for subtraction, such that a plurality of x-ray scattered radiation images which are averaged are acquired for the x-ray system. The averaging over a plurality of x-ray scattered radiation images has the advantage that the statistical noise in the resulting x-ray scattered radiation image is reduced, whereby the image quality is improved. However, the statistical noise of an x-ray scattered radiation image can also be reduced by a low-pass filter, since practically solely low frequency portions are present in x-ray scattered radiation images.

An exemplary embodiment of the invention is shown in the attached schematic drawings. Thereby shown are:

Fig. 1 an x-ray apparatus with two x-ray systems and

Fig. 2 and 3 operating schematics of the x-ray apparatus shown in Fig. 1.

The x-ray apparatus schematically shown in Fig. 1 comprises two x-ray systems 1 and 2 that, in the case of the present exemplary embodiment, are adjustable around a patient P positioned on a schematically indicated patient positioning device 3. The x-ray system 1 comprises an x-ray source 4 as well as an x-ray detector 5, and the x-ray system 2 comprises an x-ray source 6 as well as an x-ray detector 7. The x-ray source 4 and the x-ray detector 5 as well as the x-ray source 6 and the x-ray detector 7 are preferably respectively arranged (in a manner not shown) on a C-arm, whereby the x-ray source 4 and the x-ray source 6 emit conical x-ray radiation

beams. In the case of the present exemplary embodiment, the x-ray detectors 5 and 7 are solid state detectors. The x-ray systems 1 and 2 are connected with a computer 8. The computer 8, which controls the operation of the x-ray apparatus, is moreover connected with a storage 9 of the x-ray apparatus.

In the operation of the x-ray apparatus, x-ray exposures of a body region of the patient P can be acquired practically simultaneously from different angles with the two x-ray systems 1 and 2. As already mentioned above, the scattered radiation which is emitted from the body of the patient P in all spatial directions thereby disadvantageously affects the quality of the x-ray exposures of the body region of the patient P acquired with the x-ray systems 1 and 2. The generation of the less-energetic x-ray radiation 11 scattered at the body of the patient P is illustrated in Fig. 1 for the operation of the x-ray system 1, in that an x-ray beam 10 is emitted by the x-ray source 4 in the direction of the patient P as well as of the x-ray detector 5. As is to be recognized in Fig. 1, although the scattered radiation 11 is not uniform, it nevertheless radiates in all spatial directions and thus also in the direction of the x-ray detector 7 of the x-ray system 2. However, the scattered radiation 11 contributes no useful information for the acquisition of x-ray images with the x-ray detector 7. Rather, the image quality if the x-ray exposures acquired with the x-ray detector 7 is degraded by the scattered radiation 11. The applies in the same manner for scattered radiation which impinges on the x-ray detector 5 of the x-ray system 1 when an x-ray beam is emitted from the x-ray source 6 of the x-ray system 2 in the direction of the patient P and the x-ray detector 7.

In order to at least reduce the negative influence of the generated scattered radiation on the imaging with the two x-ray systems 1 and 2, it is therefore proposed to irradiate the patient P with the x-ray source 4 of the x-ray system 1 for a definite position of the two x-ray systems 1 and 2 relative to one another and to acquire a first x-ray scattered radiation image based on the radiation scattered on the patient P with the x-ray detector 7, whose x-ray source 6 is not in operation during the irradiation by the x-ray source 4. This first x-ray scattered radiation

image is stored by the computer 8 in the storage 9 as correction image for the x-ray detector 7. Given the same position of the x-ray systems 1 and 2 relative to one another, the patient P is irradiated with the x-ray source 7 of the x-ray system 2, and a second x-ray scattered radiation image based on the radiation scattered on the patient P, which is provided for the correction of an x-ray image acquired with the x-ray receiver 5 and stored by a computer 8 in the storage 9, is acquired with the x-ray detector 5 of the x-ray system 1 whose x-ray source 4 is not in operation during the irradiation of the patient P with the x-ray source 6.

A plurality of such x-ray scattered radiation images are preferably acquired for the two x-ray detectors of the x-ray systems 1 and 2 and averaged over the acquired x-ray scattered radiation image, such that a resulting x-ray scattered radiation image which exhibits reduced statistical noise is respectively acquired for each x-ray system.

If x-ray exposures of a body region of the patient P are thus simultaneously acquired with both x-ray systems 1 and 2 in the operation of the x-ray apparatus, the x-ray images acquired with the x-ray detector 7 can be improved with regards to their quality by subtraction of the first x-ray scattered radiation image saved in the storage 9. Likewise, the x-ray images acquired with the x-ray detector 5 can be improved in quality by subtraction of the second x-ray scattered radiation image saved in the storage 9. The subtraction of an x-ray scattered radiation image from an x-ray image acquired with one of the two x-ray detectors 5 and 7 is implemented by the computer 8. The x-ray images so corrected can finally be displayed in a known manner on a display device (not shown).

Normally, x-ray scattered radiation images for the two x-ray detectors 5 and 7 are determined and stored in the previously described manner in the storage 9 for different positions of the x-ray systems 1 and 2 relative to one another. The determination of the x-ray scattered radiation images thereby ensues respectively under defined acquisition conditions, by which are understood x-ray spectra, x-ray

doses and acquisition geometries. If, given the same position of the x-ray systems 1, 2 relative to one another and an unchanged position of the patient P on the patient positioning device 3, only the x-ray dose changes, no new x-ray scattered radiation image has to be determined. Rather, in that the x-ray scattered radiation images are proportional to the x-ray dose, a scaling of the x-ray scattered radiation images corresponding to the change of the x-ray dose can ensue, such that the respective x-ray scattered radiation images required for the subtraction can be determined in this manner.

Two operation schematics for the operation of the x-ray systems 1 and 2 as well as for the determination of x-ray scattered radiation images are exemplarily illustrated in Fig. 2 and 3. As can be learned from Fig. 2, the x-ray systems 1 and 2 are operated by the computer 8 such that simultaneous x-ray exposures of a body region of the patient P are acquired. As shown in Fig. 2, the x-ray source 6 is temporarily not operated for the determination of the x-ray scattered radiation image relevant for the x-ray detector 7. The same is true for the x-ray source 4 given the determination of the x-ray scattered radiation image relevant to the x-ray detector 5.

As shown in Fig. 3, x-ray scattered radiation images can also be determined given temporally offset operation of the two x-ray systems 1 and 2, since in this operation the scattered radiation also has influence on the image quality of the x-ray images determined by the two x-ray systems 1 and 2. As a rule, x-ray scattered radiation images for correction of the x-ray images determined by the two x-ray systems 1 and 2 are therefore also acquired dependent on the operation type of the x-ray apparatus, i.e. with regards to the temporal offset of the acquisition of x-ray images.

The invention was previously described with an example of an x-ray apparatus comprising two x-ray systems. In particular, however, the inventive method can

also be executed with an x-ray arrangement with two x-ray apparatuses capable of being operated independently of one another.